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# **ROAD SAFETY AUDIT CHECKLISTS: CURRENT PRACTICE AND FUTURE DEVELOPMENT**

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## **ABSTRACT**

Road Safety Audit is a relatively new tool, available to assist road agencies in lowering potential collision risk on new road schemes or highway improvements. The principles can also be extended to cover analysis of existing roads, particularly where accident data is poor or non-existent.

Audit Teams often use checklists, which prompt the auditor to consider factors which could lead to road accidents. Checklists are a useful tool aimed at helping the Audit Team during the assessment of the safety problems since they provide a good reminder of issues which need to be reviewed. However, they cannot be expected to cover all the issues which may arise in every Audit and cannot be a substitute for the safety auditor's skills and safety background.

Although checklists are helpful and are included in almost all the international Road Safety Audit guidelines, they have several drawbacks which restrict their effectiveness and use. Checklists can never cover all the safety aspects, and as checklists become more voluminous in order to be comprehensive, they become intimidating and overwhelming. Experienced Safety Audit Teams typically find such checklists redundant since the lists miss the interactivity between design elements, and threaten some of the independent and intelligent creativity of the auditor.

It is important that safety auditors base their work on sound safety experience, and where possible, have the means to back up the recommendations from documented sources. Accident control data can be used to assist safety auditors by means of effective and accessible data-bases. This assists with both the identification of problems, and with the recommendations for improvement.

This paper describes the potential for a new tool aimed at improving checklists, and at improving the effectiveness of the Road Safety Audit procedure. The tool involves the development of a computer based decision supporting system (DSS) which combines interactive checklists and control data.

## INTRODUCTION

Road Safety Audit is a relatively new tool, available to assist road agencies in lowering potential collision risk on new road schemes or highway improvements.

A Road Safety Audit is a formal safety examination of a proposed change to an existing road, or a new highway scheme which is carried out throughout the design and construction period. In the Audit, an independent, qualified team reports on the project's accident potential and makes recommendations for improvement. The principles can also be extended to cover analysis of existing roads, particularly where accident data is poor or non-existent. When the Audit process is applied to an existing road it is called a "Road Safety Review".

Road Safety Audits were first adopted in the United Kingdom in the early 1980's. The concept of Safety Audit spread to Australia and New Zealand in the early 1990's. During the past ten years Audits have been introduced, in different forms, to other countries such as Denmark, Ireland, Singapore, Malaysia, Canada and the United States.

Audit Teams can use checklists, which are a prompt aimed at ensuring that important safety problems are not overlooked. Checklists are helpful but have several drawbacks which restrict their effectiveness and use. This paper, after an overview of the Audit process and of current checklist practice, describes the potential for a new tool aimed at improving checklists.

## AUDIT PROCESS

Road Safety Audit is aimed at identifying risk factors, by trying to investigate how the road environment is perceived, and ultimately utilised by different road users. Part of the analysis involves a comparison process between the opinions expressed by a team of safety specialists (the Audit Team).

Road Safety Audit procedures involve of the following professional figures:

- the *Client*, who commissions Audits at appropriate project stages, selects an Audit Team with the appropriate training and experience, reviews the formal Audit report and acts upon recommendations whenever appropriate and feasible,
- the *Designer*, who is the responsible for the design of the project on behalf of the Client, and provides the Audit Team with all the background information to the scheme, and who responds to the initial

Audit findings on behalf of the Client,

- the *Audit Team*, which should never be a “one person Audit Team”, and should have adequate experience in road safety engineering and practices, accident investigation and prevention, traffic engineering and road design. The Audit Team identifies the safety problems of the project and provides recommendations to eliminate or mitigate them, by reviewing project documentation and drawings, and conducting site inspections.

The main steps of the Safety Audit, which may differ in different countries where the process is applied and are reported in guidelines and standards (1-16), are as follows:

- the Client selects the Audit Team,
- the Designer provides all necessary documents to the Audit Team,
- a preliminary meeting between all subjects involved is carried out,
- the Audit Team examines all project documentation and drawings, and conducts site inspections,
- the Audit Team writes the Safety Audit report, in “problem/recommendation” format, where the problem is described in terms of an accident risk to a road user, and the recommendation is an engineering solution to the reported problem. Recommendations produced by the Audit Team should indicate the type of measures, without specifying detailed technical issues,
- a completion meeting between all the participants involved is held and the proposed recommendations are examined and discussed,
- the Designer reviews the Audit report and communicates to the Client his observations with a written report addressing all safety issues,
- the Client examines Audit report and Designer’s observations and decides about the implementations of the recommendations,
- the Client responds to the Audit report with an Exception report that notes any Safety Audit recommendations that will not be implemented,
- the changes to the project, if substantial, are subjected to a new Road Safety Audit procedure,
- the process may be applied at all stages of design and should be repeated before the road is opened to traffic.

Road Safety Audits were first developed for checking the safety performance of new road designs and improvement schemes, and some of the principles have now

been extended to apply to existing roads, (Road Safety Review). The existing road network has been developed over many years and suffers basic problems: it was designed when the safety culture was not as widely accepted as it is today; traffic volume, composition and vehicle performance has evolved substantially over the years; and maintenance policy does not always take into account safety concerns.

The main objective of in-service Road Safety Reviews is to identify the technical, geometric and functional characteristics that may increase the number and/or the severity of accidents. The review can also recommend low cost measures for safety improvements which are often characterised by great cost-effectiveness.

Safety Reviews may be part of a national comprehensive road safety strategy since they represent a low cost method for the periodic evaluation of network safety performance, and the programming of safety improvements. In countries where accident data is not collected and “blackspot” remedial programs are not in use, Safety Reviews are a suitable methodology for starting systematic safety improvements programs, whilst in countries with more evolved safety management the Review can be used to support blackspot analysis.

## **CURRENT CHECKLISTS OVERVIEW**

Checklists are aimed at ensuring that important safety problems are not overlooked. Checklists are a prompt and not a substitute for knowledge and experience, that is, checklists should aid using safety engineering experience and judgement and should not be used as “tick” sheets (4). New safety auditors find checklists very useful, whilst as their experience grows they use checklists less often.

Checklists, although in different forms, are included in all the international Road Safety Audit guidelines and reflect what safety engineers believe are the most common safety problems. A brief overview of the current checklists practice is below reported.

### **Australia**

Austroads guidelines on Road Safety Audit (1) provide comprehensive checklists. There is a set of checklists for each of the five Audit stages: feasibility, draft design, detailed design, pre-opening, existing roads. For each stage, checklists are divided into sections; for example for existing roads, 10 sections exist: general topics, alignment and cross section, intersections, auxiliary lanes and turn lanes, non motorised traffic, signs and lighting, traffic signals, physical objects, delineation,

pavement.

### **Canada**

The Transportation Association of Canada is preparing Canadian Guidelines for Road Safety Audits. The draft version of the guidelines is based on very short checklists, which are only a reminder to the Audit Team of the topics that need attention for their implications on road safety. The University of New Brunswick Transportation Group has developed detailed checklists (16). Four series of checklists have been developed: two of the checklists apply to highway Audits, and two apply to municipal Audits. For each case, there is a master checklist and a detailed checklist. The master checklist provides the Audit Team with a list of the topics to be considered, depending on the stage of the design, and the detailed checklists elaborate on the topics contained in the master checklist.

### **Denmark**

The Danish Manual of Road Safety Audit (7) contains fifteen checklists: initial design, draft design, detailed design, opening, monitoring, minor improvements on road sections, speed reduction, priority controlled junctions, traffic signals, roundabouts, junctions between paths and roads, cycle paths and pedestrian areas, maintenance work, local development plan proposal, road safety improvements scheme. The checklists are extensive.

### **Italy**

The Italian guidelines (6) report contains voluminous checklists, which are also coupled with a detailed explanation. Road Safety Audit guidelines have been drawn up following pilot Road Safety Audits, and are aimed at spreading Road Safety Audits, which have not been applied in the country before. Therefore, checklists have been prepared as a training for new road safety auditors.

### **New Zealand**

New Zealand checklists (10) are similar to the Austroads checklists.

### **United Kingdom**

The checklists attached to the IHT 1996 guidelines (4) are much shorter than the ones in the IHT 1990 guidelines (3) and provide only a short guide on the principal issues to examine, not the technical details.

## **CURRENT CHECKLISTS DRAWBACKS**

Although checklists are helpful and are included in almost all the international Road Safety Audit guidelines, they have several drawbacks which restrict their effectiveness and use. Checklists can never cover all the safety aspects, and as checklists become more voluminous in order to be comprehensive, they become intimidating and overwhelming. Experienced Safety Audit Teams, which consist of safety experts trained and experienced in conducting Audits, typically find large checklists redundant since the lists miss the interactivity between design elements, and threaten some of the independent and intelligent creativity of the auditor.

Indeed, in countries where the Road Safety Audit process is widespread, checklists tend to be more concise and become only a short list of prompts for the Audit Team.

## **CONTROL DATA**

It is important that safety auditors base their work on sound safety experience, and where possible, have the means to back up the recommendations from documented sources. There are a number of reasons for this:

- to try to avoid basing Audit comments on road safety “myths”,
- to try to avoid basing Audit comments on “gut feelings” about safety,
- to avoid wasting time on non-safety issues within the design process,
- to increase cost effectiveness of the recommendations.

The ideal situation would be one in which an auditor could turn to a published source to answer specific safety questions. Ideally, the background reasoning or “control data” would contain information from similar sites in order to predict accident types and accident numbers.

Data is easier to obtain for more substantial elements of scheme design (for example choice between junction types) than for smaller elements (for example the size of the letter height of signs).

Control data should be used to assist safety auditors with both the identification of problems, and with the recommendations for improvement. In the first part, the auditor is trying to determine who is most at risk in the new layout. In the second part, the auditor tries to suggest an improvement that has been previously demonstrated to mitigate that risk. Local control data is very important, as accident

performance varies from one part of a country to another.

## **ADVANTAGES AND BASIC PRINCIPLES OF INTERACTIVE CHECKLISTS**

Many parts of the world do not have the detailed accident investigation experience referred to above. This may be because accident data is poor or non-existent, or it may be because there is no culture of accident investigation.

Either way, this leaves those who would introduce Road Safety Audit with a dilemma – unless the Audit is based on sound safety principles it may be a waste of resources. Unless the process identifies and prevents from occurring genuine accident problems, it may simply add to the bureaucracy and cost of the scheme as it proceeds through the design stages – without any real benefit in terms of accident prevention.

One solution to this problem is costly training of staff, although it is unlikely that this safety engineering experience can be taught effectively on short vocational courses. Another answer may be to buy in overseas consultants to carry out audits – but this is not sustainable in the long term.

One solution not yet tried would be to try to capture the safety engineering knowledge from existing experts and from published sources, and put it into an interactive checklist system that could be interrogated by new Road Safety Auditors. Such system could be useful also for more expert Auditors providing them information and suggestions.

The checklists would sit on a WINDOWS based application, and have multi entry access. Users would be able to specify either scheme type, (for example rural single carriageway roundabout junction), or road user type, (for example child pedestrian), or a combination of both. Once into the system, the user could call up likely accident types identified by Safety Engineers for that feature or road user (or combination) based on well documented research. In addition, the user could call up the types of problems and recommendations commonly identified by Safety Auditors.

The philosophical goals of the system are:

- the ability to understand how real accidents happen, and to understand what type of accident (and in some case how many accidents) can take place in relation to the characteristics of the traffic and of the road,
- the ability to understand if a standard non-compliance or a road deficiency



gives rise to consequences in terms of increasing the number and/or the severity of road accidents,

- the ability to analyse the needs of all the types of road users, or rather to see the projects and the existing roads from the point of view of pedestrians, children, cyclists, drivers of commercial vehicles, disabled persons, etc., and not only of the car driver,
- the ability to suggest recommendations that are effective and practicable solutions to individual problems, that is, solutions that have already shown their effectiveness in the accidents reduction in circumstances similar to those to be audited.

Practical features of the system should include:

- the ability to store abstracts or entire reference sources,
- the ability to store photographs of problems and recommendations,
- the ability to print off relevant parts of the checklist,
- an exploration of the possibility of incorporating standard solutions to pre-defined problems, and to use this within a report writing package to ensure greater consistency of Safety Audit reports,
- the ability for a user to add to the checklist and reference sources from local data,
- easy to use flexible search facilities,
- links to other databases,
- an accident database that could be analysed so that users could answer specific queries,
- the ability to translate into different languages.

To each the above said goals, interactive checklists will be structured in five sections:

- the first section is a user-friendly interface. The analyst defines the situation to be audited, and the interactive checklist provides data needed for giving more accuracy in predicting accidents and in understanding the interaction between road user and the road,
- the second section, based on the previous data, suggests type of accidents and common problems,
- third section is a link with control data to be used for risk assessment,
- fourth section gives information on costs and benefits of the solutions that have already shown their effectiveness in the accidents reduction in

- circumstances similar to those to be audited,
- fifth section aids risk assessment in the different suggested scenarios.

## **EXAMPLE OF THE INTERACTIVE CHECKLISTS**

To date, TMS Consultancy is starting to develop an interactive checklist system. Some aspects of the system, divided into five basic sections, are explained below and a demonstrative example is given. This example is one of a number of potential pilots that are currently being examined.

### **Section 1**

The first part of the system will require input data from the user. Interactivity already begins in this phase, since suggestions relating to useful information are given to the auditor.

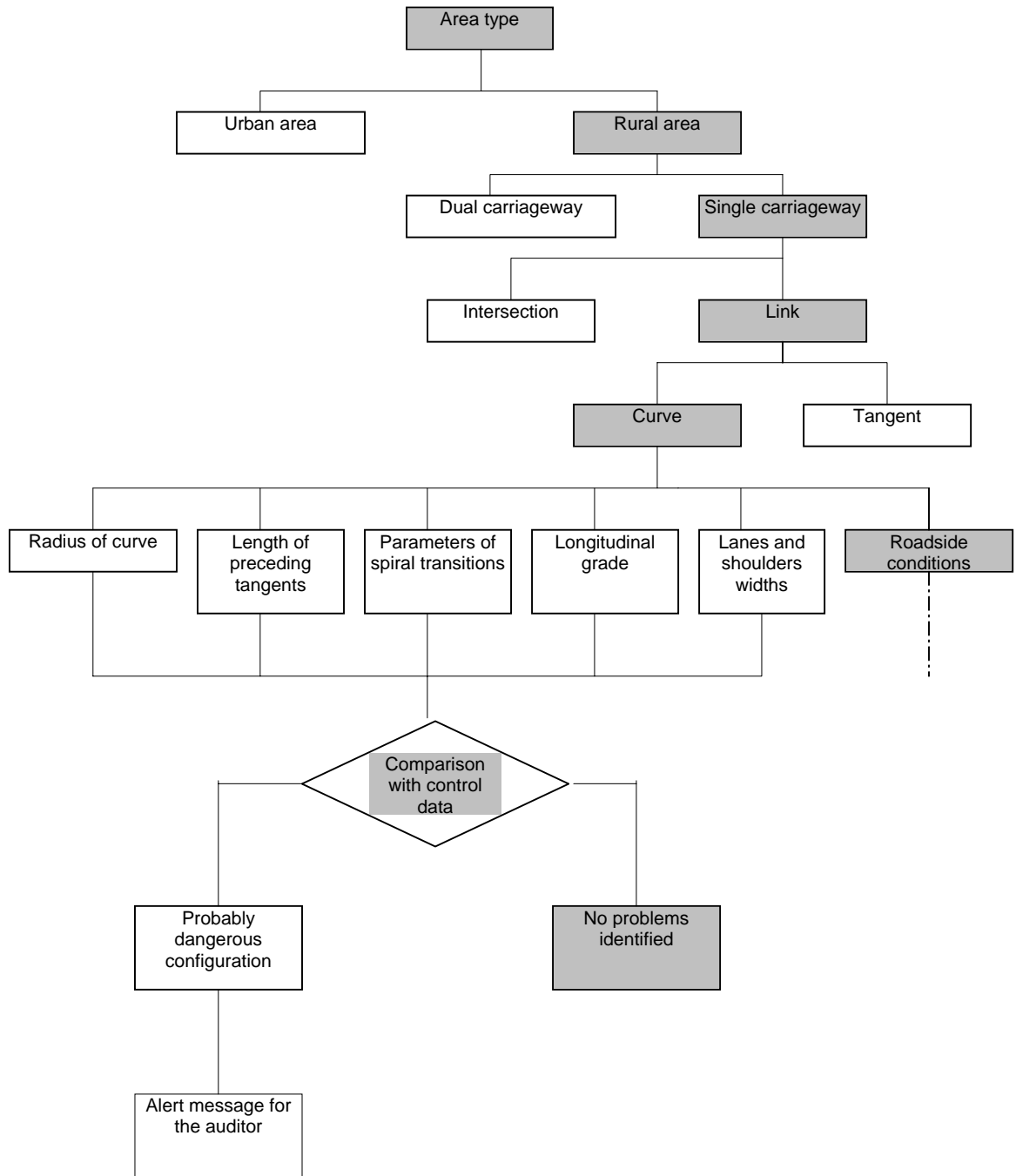
Input data are divided into three sub-sections:

- audit stage,
- road user information,
- road features.

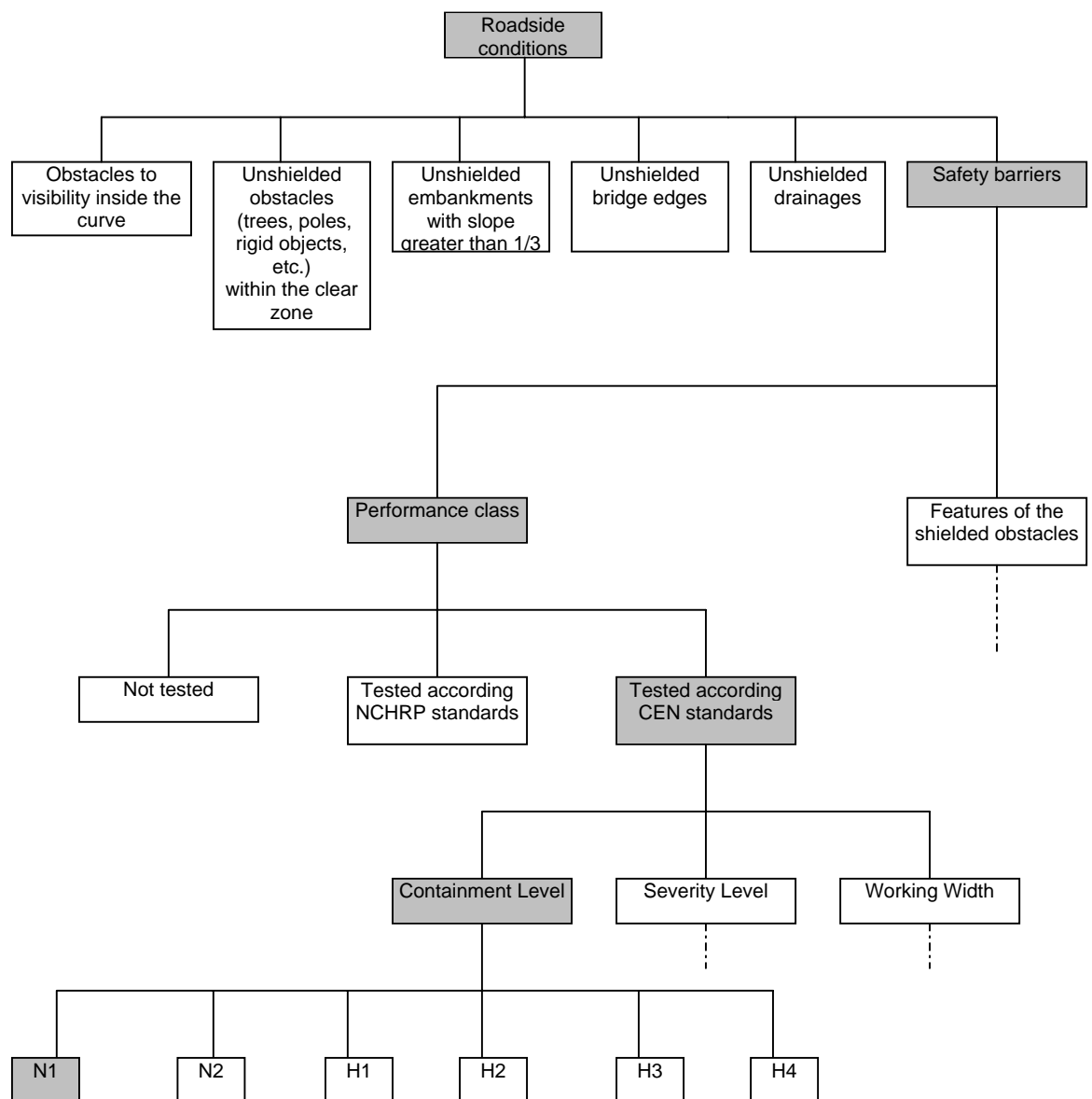
The audit stage is defined by the auditor. In the example, a detailed design Audit has been assumed.

Road user information is needed to identify the features which are most related to a specific category of users. In the example, it has been assumed that the analysis covers all users.

Road features input covers the basic road features that may affect safety. In figure 1 a diagram of the main information required from the system is reported. Each answer leads to a different branch of the tree. In the example, roadside conditions (see figure 2) are analysed in more detail, due to the installation of a safety barrier with Containment Level N1, that is the minimum Containment Level of the new CEN standards (19, 20).



**FIGURE 1 Road features input.**



**FIGURE 2 Roadside conditions input.**

In the example, the road feature to be examined by the auditor is the safety barriers' containment level. If doubts about risk factors associated with one feature exist, the auditor will click a "help" button. The checklist associated with the feature will be shown (see table 1). The checklist would prompt the auditor with some issues to be checked, but will not be exhaustive.

**TABLE 1 Checklist for Safety Barriers Containment Level Adequacy**

Item	Issues to be considered
Safety barriers containment level adequacy	Have the safety barriers been successfully crash tested? Have suitable methods been used for the selection of safety barriers performance classes? Are the containment levels of the safety barriers adequate to the kind and location of the hazards? Are the containment levels of the safety barriers adequate to traffic volume and composition? Are the containment levels of the safety barriers adequate to the functional class and geometrical features of the road (horizontal curvature, longitudinal grade, number of lanes, lanes width, shoulder width, etc.)? If the safety barriers have not been crash tested, are their features adequate to the above said hazards?

## Section 2

In the case study, Italian accident data for two-lane rural highways have been used as a reference. The database should contain local accident data from different countries. Since the problem to be studied relates to the roadside, data on run-off-the-road accidents are presented to the auditor. The data show that single vehicle run-off-the-road accidents are of great consequence:

- 22% of all injury accidents,
- 23% of all fatalities,
- 18% of all injuries.

## Section 3

Local accident data will be compared with the input data. The comparison shows:

- in sites similar to the audited site, single vehicle run off the road accidents are a relevant problem,
- the specific features of the audited site show that a run-off-the-road accident could cause serious or fatal injuries if the safety barriers are not able to contain the errant vehicles, due to the presence of an embankment with an height equal to 6 m and a slope equal to 2/3,
- the proposed safety barriers have a low Containment Capacity,
- an analysis of cost effectiveness of alternative measures is needed.

## Section 4

Benefits and costs of practical and already successful improvements are assessed. Within the case study, the interactive checklist will be linked with the program

SAFBAR (22-23) and alternatives consist of installation of safety barriers with higher Containment Level.

The program will compare safety alternatives taking into account factors such as type and features of the road, traffic volume and composition, type and features of the obstacles, distance of the obstacles from the carriageway, performance level of safety barriers, cost of any level of injury. For any alternative, the procedure will give the following results:

- number of accidents,
- severity of accidents,
- cost of accidents,
- cost of safety measures.

## Section 5

The incremental benefit/cost ratios between each pair of safety alternatives will then be calculated using the formula:

$$B/C_{2-1} = (CC_1 - CC_2) / (DC_2 - DC_1) \quad (1)$$

where:

$B/C_{2-1}$  = incremental B/C ratio of alternative 2 to alternative 1;

$CC_1, CC_2$  = annualised crash cost for alternatives 1 and 2;

$DC_1, DC_2$  = annualised direct cost for alternatives 1 and 2.

Alternatives will be sorted by increasing direct cost and the audit team has to decide the threshold of the B/C ratio. If the B/C ratio is greater than the threshold, the safety alternative of greater cost is the best choice.

In different circumstances, benefit-cost or cost-effectiveness analyses will be performed using accident predictive models and accident modification factors reported in the safety literature (8, 21) and in the TMS research database.

If accident control data of the system are not specifically suited for the examined problem, a qualitative risk assessment could be carried out using a risk assessment matrix. Severity and number of accidents will be estimated, and a risk score (high, medium, low) for each alternative is given.

**TABLE 2 Risk Assessment Matrix**

<b>Accident frequency</b>	<b>Low frequency</b>	<b>Medium frequency</b>	<b>High frequency</b>
<b>Accident severity</b>			
<b>Low severity</b>	low risk	low risk	medium risk
<b>Medium severity</b>	low risk	medium risk	high risk
<b>High severity</b>	medium risk	high risk	high risk

## **CONCLUSIONS**

Checklists are an important tool for undertaking Road Safety Audits, but can never cover all the safety aspects, and as checklists become more voluminous in order to be comprehensive, they become intimidating and overwhelming. Furthermore, it is important that safety auditors base their work on sound safety experience, and where possible, have the means to back up the recommendations from documented accident control data.

The interactive checklist system presented in the paper could aid both experienced and new auditors, since it captures the safety engineering knowledge from existing experts and from published sources. The system will help an auditor during the identification of the problems and should allow for detailed comparison between the recommended alternatives, basing decisions both on benefit/cost analyses and on risk assessment.

TMS Consultancy will continue to pilot the concept, and is looking for additional research or commercial funding to develop the concept on a wider basis.

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